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RF RADIATION HAZARD STUDY

WCBD--TV

The purpose of this report is to analyze the non-ionizing radiation levels for a KU Band Uplink earth station using a 2.4 meter dish antenna. The Office of Science and Technology Bulletin, No. 65, August 1997, specified that the maximum level of non-ionizing radiation for this frequency range that a person may be exposed to over a 0.1 hour (6 minute) period is an average power density equal to 5 mW/cm^2. It is the purpose of this report to determine the power flux densities of the earth station in the near field, transition region, far field, the main reflector surface, and between the antenna edge and the ground.

The following parameters were used to calculate the various power flux densities for the earth station:

Antenna Diameter, (D)	= 2.4 meters
Antenna Surface Area, (A)	= $\pi(D^2)/4 = 4.5\ m^2$
Wavelength at 14.25 Ghz, (λ)	= 0.021 meters
Transmit Power at Flange, (P)	= 350 watts max
Antenna Gain, G, dBi	= 49.2 dBi
Antenna Gain, G, linear	= $10^{(49.2/10)}$ = 83176
π	= 3.1416
Antenna Aperture Efficiency, (n)	= 0.65
OET Safe Power Density Limit (S)	= $5.0 mW/cm^2$

Near Field Region Calculations

Power flux density is considered to be at a maximum value throughout the entire length of this region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the extent of the near field region, the power density decrease with distance from the transmitting antenna.

The near field distance limit can be calculated by the following equation:

$$R_{nf} = D^2/(4*\lambda) = (2.4)^2/(4*.021) = 68.6 \text{ meters}$$

The power flux density (S) within the near field distance on axis with the antenna is calculated by the following equation:

$$S_{nf} = (P*16*\eta)/(\pi*D^2) = (350*16*0.65)/((\pi*(2.4)^2) = 201 \text{ W/m}^2 = 20.1 \text{ mW/cm}^2$$

Transition Region Calculations

The transition region is located between the near and far field regions. The power flux density decreases inversely with distance in the transition region. The maximum power density in the transition region will not exceed that calculated for the near field region, in this case 20.1 mW/cm^2. The power flux density at a particular distance, R, within the transition region can be calculated by the following equation:

$$S_t = S_{nf}*(R_{nf})/R$$

Far Field Region Calculations

The far field region is all space that is located at such distances that the power flux density varies as the square of the distance from the source antenna. The beginning of the far-field region can be calculated from the following equation:

$$R_{ff} = 0.6*D^2/\lambda = 0.6*(2.4)^2/.021 = 165 \text{ meters}$$

The power flux density, S_{ff} , at the beginning of the far field region can be calculated by:

$$S_{ff} = (P*G)/(4*\pi*R^2) = (350*83176)/(4*\pi*(165)^2) = 85.1 \text{W/m}^2 = 8.51 \text{mW/cm}^2$$

Safe Region on Axis Power Flux Density Calculations

The region of far field where the RF exposure equals the maximum allowed power flux density is the minimum safe distance for the time duration specified for an individual.

The distance at which the RF exposure is safe for the prescribed time duration indicated in the OET-65 bulletin can be re-arranging the equation on he previsous page and calculated as:

$R = \text{Sq. Rt.} \{(P*G)/(4*\pi*S_{ff})\} = \text{Sq. Rt.} \{(350*83176)/(4*\pi*50)\} = 215$ meters

Main Reflector Region Calculations

Transmissions from the feed assembly are directed toward the main reflector surface.

The power density in the main reflector region can be calculated by the following:
$S_{mf} = 2(P)/A = 2*350/(4.5) = 167\ W/m^2 = 16.7\ mw/cm^2$

Off Axis Antenna Region Calculations

Off axis reduction in gain is given by the antenna characteristics. Sidelobe level for the dish antenna used in this installation is given by:

Off Axis Angle	Sidelobe Envelope
$(100*\lambda/D)° < \theta < 20°$	29-25*Logθ dBi
$7° < \theta < 9.2°$	-3.5 dBi
$9.2° < \theta < 48°$	32-25*Logθ dBi
$48° < \theta$	-10 dBi

Off Axis Near Field Calculations

Antenna RCAGL for this installation is 2 meters. The minimum elevation angle of the antenna is -10 degrees with respect to the horizon. The antenna uses an offset feed assembly that is offset by 22.6 degrees resulting in the minimum main elevation angle of the on axis signal being 22.6 – 10.0 = 12.6 degrees. With an off axis angle of 12.6 degrees and assuming the lowest point of antenna dish is at 2 meters, (equivalent of a person of standard height), the gain of the antenna is 32-25 log(12.6) = 4.5 dBi.

To calculate S_{nf} for the off axis area, the power can be reduced by the gain factor of the antenna at the off axis angle versus the power used for the on-axis S_{nf} value. The reduction of power is 49.2-4.5 dB = 44.7 dB, and $10^{44.77/10} = 29512$

$S_{nf} = (P*16*\eta)/(\pi*D^2) = ((350/29512)*16*0.65)/((\pi*(2.4)^2) = .007\ W/m^2 = .0007\ mW/cm^2$

Off Axis Far Field Calculations

Antenna RCAGL for this installation is 2 meters. The minimum elevation angle of the antenna is 10 degrees. With an off axis angle of 10 degrees and assuming the lowest point of antenna dish is at 2 meters, (equivalent of a person of standard height), the gain of the antenna is 32-25 log(12.6) = 4.5 dBi.

To calculate S_{ff} for the off axis area, the power can be reduced by the gain factor of the antenna at the off axis angle versus the power used for the on-axis S_{nf} value. The reduction of power is 49.2-10 = 39 dB. Thus the gain of the antenna is 10 dBi and the resulting RF exposure is significantly lower and calculated below.

$S_{ff} = (P*G)/(4*\pi*R^2) = (350*2.82)/(4*\pi*(165)^2) = 0.003 W/m^2 = 0.0003\ mW/cm^2$

SUMMARY OF RESULTS AND CONCLUSIONS

Region	***Calculated Maximum Radiation Level mW/cm²***	***Hazard Assessment***
On Axis Near Field Region (68.6 Meters)	20.1	Potential Hazard
On Axis Transition Region	8.51	Potential Hazard
On Axis Far Field Region	8.51	Potential Hazard
Main Reflector Area	16.7	Potential Hazard
Off Axis in near Field antenna region.	0.0007	None
Off Axis Far field Region	0.0003	None

The proposed uplink facility will have potential hazards only when personnel are close enough to be in the on-axis region of the antenna. In this case, the uplink area of operation is fenced off so that only Occupational and Service personnel can access the area. Thus the station must be shut off anytime that an individual is working in the main reflector or on axis area. In the case where personnel are off axis, such as outside the fenced area no hazard exists with transmission occurs even at the general population exposure limit of 1 mW/cm^2. The RF exposure level 0.5 meter away from dish off axis is still 0.0007 mW/cm^2 so no hazard exists.

Since no buildings or any other circumstance will exist for people to be located at distances below the safe distances for On-Axis radiation, the only time a reduction in power is needed is when maintenance or service is performed on the dish.